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ANALYSIS OF REFLECTOR PATTERN IN DIFFERENT FREQUENCY RANGES IN THE BACKWARD HEMISPHERE

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ABSTRACT.
The reflector directional characteristics determination method grounded on the usage of the second kind Fredholm integral equations for "jumping" of the current surface density is offered.

When using the thin absolutely conductive unenclosed shield as an antenna, the exact calculation of the distant side and backward radiation is possible if we use the Fredholm first kind integral equations. The solution of the second kind integral equations for the diffraction problems on unenclosed shields with boundary conditions the Dirichlet and Neumann types are considered in [1, 2]. However it is difficult to algorithm the obtained three-dimensional problems solutions in the special functions class. This limits the feasibilities of the numerical method usage when calculating real unenclosed constructions. The purpose of this article is the development of the Fredholm second kind integral representations operation theory for calculation of reflector spatial characteristics as a paraboloid of rotation in quasi-optical range ($D/\lambda=10$). When calculating exactly it is necessary to bear in mind that the behavior character of surface currents in the central part of a reflector and in the boundary zone can considerably differ from each other [4]. The calculation and registration of "edge" currents allow to calculate exactly the intensity of the distant side and back radiation.
If we enter a concept of the current surface density "jumping" [1] on a surface, defined as $\vec{K}=\left(\vec{H}_{\perp}\right)^{+}-\left(\vec{H}_{\perp}\right)^{-}=\vec{J}_S^{+}-\vec{J}_S^{-}$, the solution of the delivered problem outside an ideally conductive surface S can be expressed through tangent components of electrical and magnetic vectors on the surface S

$$\vec{H}(M)=\vec{H}_0(M)+\frac{1}{4\pi}\oint_S\left\{grad_P\frac{\exp(-ikR_{MP})}{R_{MP}}\times\vec{K}(P)\right\}dS. \qquad (1)$$

Where R_{MP} - the distance between the M and P points (P - a point on a surface S, M – a view point), $\left(\vec{H}_{\perp}\right)^{+},\left(\vec{H}_{\perp}\right)^{-}$ - the normal to a surface of a component of a magnetic intensity on the internal (lighted) and external (shadow) mirror surface sides, $\vec{J}_S^{+},\vec{J}_S^{-}$ - the area current density on the internal and external reflector sides.
If we multiply (1) by $\vec{n}_{P_0}$ and to aim on a normal the M point to the P_0 point of the surface S, then, using the properties of a simple stratum potential normal derivative, we shall receive the Fredholm second kind representation:

$$\frac{1}{2}\left(\vec{J}_S^{+}(P_0)+\vec{J}_S^{-}(P_0)\right)=\vec{J}_S^{0}(P_0)-\frac{1}{2\pi}\int_S \vec{n}_{P_0}\times\left[\left(\vec{J}_S^{+}(P)-\vec{J}_S^{-}(P)\right)\times grad_P\frac{\exp\left(-ikR_{PP_0}\right)}{R_{PP_0}}\right]dS \qquad (2)$$

The task of determining the volumetric current density distribution is reduced to a repetitive process, at each stage of which the Fredholm second kind integral equation concerning the area current density on the lighted $\vec{J}_S^{+}$ or on the shadow $\vec{J}_S^{-}$ side of the reflector with an updated right side, is solved. The iterative procedure application allows to update the area current density value on both sides of a reflector in the boundary area essentially influencing the distant side and back radiation. It allows to reduce the integration area and to reduce the run time. For implement a numerical algorithm determining the area current density $\vec{J}_S^{-}(P_0)$ or $\vec{J}_S^{+}(P_0)$ on the surface S, it is dissected into N of not intersected cells. The sizes of the cells can be selected 0,1λ (λ - wavelength) [3]. The Focks equation for the surface current density, for example, on the external side of S, will look like

$$\begin{aligned}&\vec{J}_S^{-}(P_0)-\frac{1}{2\pi}\int_S \vec{n}^{e}(P_0)\times\left[\vec{J}_S^{-}(P)\times grad_P\frac{\exp\left(-ikR_{PP_0}\right)}{R_{PP_0}}\right]dS=\\&=2\vec{J}_S^{0}(P_0)-\vec{J}_S^{+}(P_0)-\frac{1}{2\pi}\int_S \vec{n}^{e}(P_0)\times\left[\vec{J}_S^{+}(P)\times grad_P\frac{\exp\left(-ikR_{PP_0}\right)}{R_{PP_0}}\right]dS\end{aligned}, \qquad (3)$$

Because of the boundary conditions the Meixner conditions for the surface current density will be as follows: components which are orthogonal to the edge will have the feature of the aspect $\rho^{-1/2}$, and components which are parallel to the edge will have the aspect $\rho^{1/2}$ [4]. Then the solution is searched as

$$j_x^{-/+}=\rho^{1/2}\sum_{n=1}^{N}\dot{A}_n\Psi_n,\qquad j_y^{-/+}=\rho^{-1/2}\sum_{n=1}^{N}\dot{B}_n\Psi_n,\qquad j_z^{-/+}=\rho^{1/2}\sum_{n=1}^{N}\dot{C}_n\Psi_n, \qquad (4)$$

where ρ is the distance to the edges of a mirror, $\dot{A}_n,\dot{B}_n,\dot{C}_n$ are unknown factors, Ψ_n is known system of functions, N is amount of surface segments.

When we hold numerical calculations a collocation method is used. The Haar system of characteristic functions was selected as Ψ_n [3]. If the integration points coincide the kernel has a feature, to eliminate which, it is excised by a circle with the radius $\varepsilon=10^{-6}\lambda$ [3]. The presence of the feature allows to generate a system of linear algebraic equations with a dominant principal diagonal. In fig. 1 the relation of the K_y component of the surface current density for f=1GHz is shown. Curve 1 corresponds to the physical optics approximation, curve 2 - current density obtained on the basis of the integral equations solution considering the boundary conditions. From fig. 1 we make an important conclusion that when we determine the currents it is necessary to carefully calculate the

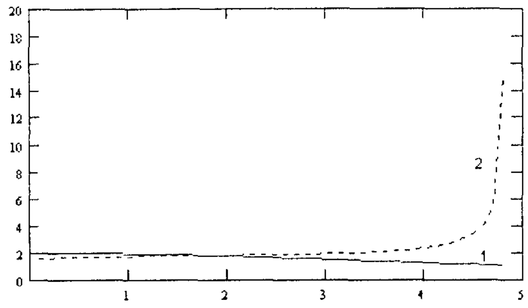

Fig. 1. The K_y component

boundary area making approximately 0,5λ from the mirror edge, and we can use a physical optics approximation for the rest.

Knowing the distribution of currents on a surface, we can determine the directivity diagram in a far-field region (fig. 2).

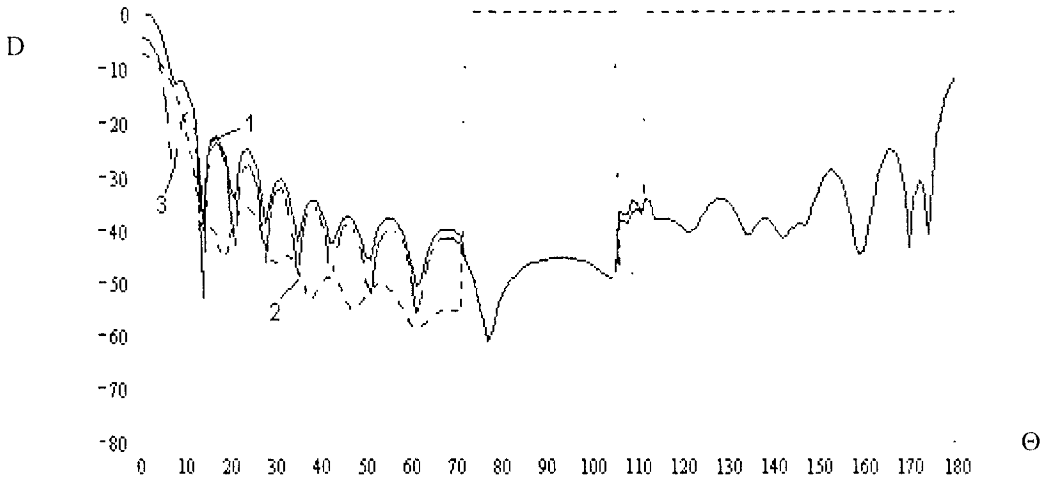

Fig. 2. The pattern of a reflector (f=1 a GHz)
(1 - total field, 2 - field created by a boundary part, 3 - field created by a central part)

From the data, shown in the figures, it is possible to make some more important practical conclusions concerning reflector characteristics calculation: 1. The basic contribution to distant side lobes is given by the edge, which at angles more than 15^0 determines the shape of the whole pattern; 2. The registration of "becoming numb" currents allows to determine the level of the reflector back radiation - it diminishes with the increase of frequency and makes about -40 dB for this construction.

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